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ABSTRACT

This museum study advances knowledge on science teacher learning that takes place outside of the formal institution or college and describes the types of collaboration and resource sharing that are required to do so. A case study documents a "curriculum for teachers" initiative that evolved out of current science education reform. It highlights a series of resources and approaches that extend the college experiences, not replace them. The report provides an introduction to the museum's infrastructure for working with teachers and teacher education institutions and provides a chronology of the activities of the study. It concludes with a discussion of the preliminary findings and a summary of five salient cornerstones of the work: (1) pay attention to reform policies and standards for science teaching; (2) structure museum learning opportunities in the same ways that formal programs do; (3) exercise scholarship through evaluation, revision, and dissemination of initiatives; (4) respect the mission and vision of partner institutions; and (5) maintain clarity in the fact that this program is not just about institutionalization--ultimately it is about facilitating access to knowledge and resources. (Contains 21 references.) (MVL)

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A Science Museum's Expedition into the World of Formal Teacher Development: The First Three Years of a Five-Year Action Research Study

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An expedition brings to mind a planned journey to a place where one hopes to reach a specific objective. Like research scientists at our Museum who often go on expeditions in search of scientific explanations to proposed theories or to advance prior knowledge, our education department is exploring how Museum experiences may best be infused as "formal" or "institutionalized" requirements for teacher preparation and development. When scientists participate in expeditions, they are prepared with their questions, their field instruments, additional resources to make last minute adjustments, tools to collect and document their findings, and their hopes for success that will advance knowledge in their field. Sometimes, they find one more famous fossil they predicted would be found in a particular area or discover new creatures living without sunlight at the bottom of the ocean. Other times they return with more questions - but maybe without the fossils, the endangered fish, or the appropriate sample or specimen they set out to find. In all cases, the research continues, changes are made, new perspectives considered, funding is sought, the work goes on, and new methods and theories evolve.

We use the "expedition metaphor" to report on our study because it is relevant to our context. The American Museum of Natural History (AMNH) is a Museum with more than 200 scientists and 100 educators. We have policies established by our administration that require scientists to make contributions to education and for educators to respond to the policies and needs of schools and teachers in New York City. We have extensive resources and we are a public institution with a mission to serve the public by exhibiting and interpreting knowledge in science and culture. We are over 130 years old and working with educators has always been part of our history. Most of these relationships are treated as contributions from an "informal" institution; however, this particular initiative is focused on formalizing our contribution to teacher development. It is supported by an infrastructure designed to reach our goal - but we are not there yet.

So far, we have benefited from Museum policies and fiscal commitments that favor education; the vision and flexibility of the leadership at partner institutions; generous philanthropy; and teacher educators and teachers whose participation validate

the journey. In addition, the timing and climate of reform that accompanies the pressing need for certified science teachers - has made this expedition a *tour de force* for science educators in this large urban setting.

In three years we have been able to develop Museum-based learning experiences using traditional mechanisms of the field but with different configurations and approaches. Among these are courses that are taught in a combination of classrooms, labs, parks, and the Museum exhibits. We have summer institutes that are attended by educators at all levels of K-12, college faculty, and administrators. We use on-line technologies for professional development to bring the collections, scientists, and their research to those beyond New York. Teams comprised of scientists, teacher educators, and teachers do all our instruction. Our professional development programs are offered to schools, districts, and colleges.

This study is framed from the Museum perspective. Theoretically, it hopes to advance knowledge on science teacher learning that takes place outside of the formal institution or college and to describe the types of collaboration and resource sharing that are required to do so. The study does not claim to be a new approach to teacher education in general or a study on teacher recruitment or enhancement. It is a case study that documents a "curriculum for teachers" initiative that evolved out of current science education reform. It highlights a series of resources and approaches that extend the college experiences – not replace them. In the descriptions of year two we bring the voices of two CUNY educators and scientists (Sloan, Miele) to show the reciprocal nature required of this type of initiative. All of us have had to make adjustments and trust that we are all after the same objective: the preparation of teachers who can teach and learn in a variety of contexts so that they and their students are fully prepared to take advantage of the scientific richness of this urban setting.

We organized our report in five sections. Section 1 is an introduction to the Museum's infrastructure for working with teachers and teacher education institutions. Sections 2, 3, and 4 provide a chronology of the activities during the first three years of the expedition. Section 5 concludes with a discussion of preliminary findings and a summary of five salient cornerstones of this work:

1. Mindfulness of reform policies and standards for science teaching;
2. Structure Museum learning opportunities in the same ways that formal programs do (courses, seminars, institutes, contact hours, performance assessments, credits);
3. Exercise scholarship through evaluation, revision, and dissemination of initiatives;
4. Respect the mission and vision of partner institutions;
5. Maintain clarity in the fact this "expedition" is not just about "institutionalization" – ultimately – it is about facilitating access to knowledge and resources.

In Years 4 and 5 we expect to be able to report on the "how" and "what" of structures and programs that have passed the test of institutionalization as well as on any unintended results. At that time we will do a deeper analysis of the policies, approaches, funding, and visions that support or hinder this type of expeditions.

1. The Context or Infrastructure Designed to Support the Expedition

Most expeditions are based on theories or prior knowledge. We too needed to bring valid experiences with schools, teachers, and higher education to the teacher education infrastructure in New York City. We focused first on the funding and development of school relationships, a teacher faculty with research experiences; and the formation of a Museum-based higher education team.

- **School Partnerships:** Several years before exploring "formal" teacher education, the Museum began to develop an infrastructure for extensive collaboration with schools and educators. It began with schools partnerships. The vice-president for education at the Museum developed close partnerships with various schools at the elementary, middle and secondary level. These partnerships emerged from initiatives to create and study new small schools or schools within schools following the tradition of houses that had been initiated at universities and also documented in research on schools (Lightfoot, 1983; Louis and Miles, 1990; McLaughlin, Talbert, Khane and Powell, 1990).

The premise was that small schools connected to the Museum would provide students and teachers with additional resources such as scientists, exhibitions, and classrooms. Teachers and students would be socialized into Museums as places of learning. The Museum would learn how teachers and students used its resources as part of their regular curriculum and policies – rather than in traditional form of school trips. Scientists, Museum educators, and educational technology developers would be able to shape and develop resources for schools that were developed and field-tested in real classrooms over time. One of these schools also was also a professional development school for Teachers College, Columbia University (Lythcott & Schwartz, 1994) and provided us with knowledge of how novice teachers used the museum as a teaching context. To serve these partnerships the Museum designated classroom spaces and hired Museum educators who teach and serve as liaisons between the schools and the Museum. Local colleges often place student teachers in these schools and national and international visitors come to observe and video tape the learning and teaching that happens in these settings. Currently we work with one private school and five public schools. Recently, we have begun to see these schools getting public

recognition. For example, The New York City Museum School was recently cited as one of the twenty best high schools in the city (Hemphill, 2001). Thus, the work with schools validates the formal role of the Museum in the public and private school sector.

(Exhibit A- School Article)

- **Teachers on Expeditions**: In 1997 AMNH initiated the funding and development of a faculty of teachers who would participate in scientific research experiences and assist in the development of Museum programs for teachers. Research indicated that teachers' lack of content and process experiences "doing science" during their preparation prevented them from teaching science as inquiry (Lawson, 1989;Kennedy, 1997). The development of the National Science Standards was also forcing the issue of science as inquiry (National Research Council, 1996). In addition, the National Science Foundation was recognizing that unless scientists contributed to education, rapid changes in scientific knowledge would not be readily available to schools. Teachers in NSF funded programs such as Teachers Experiencing Antarctica and the Artic (T.E.A) were going on expeditions to study with scientists connected to research institutions (TEA.rice.edu). Results from the study of strategies for effective professional development of math and science teachers (Loucks-Horsley, Hewson, Love, & Stiles, 1998) also recognized "immersion of teachers into the world of scientist" as an effective approach to develop content and inquiry.

AMNH sponsored a group of teachers that upon their return joined Museum scientists and educators as teaching faculty in professional development programs. The vise-president for Education, Myles Gordon, joined the first group of NYC teachers participating in an expedition to the Juan de Fuca Ridge to recover hydrothermal vent chimneys. An expedition organized by the University of Washington that included an educational component known as REVEL (Research and Education: Volcanoes, Exploration, Life (www.ocean.washington.edu). NOVA documented this expedition (Volcanoes of the Deep) because of its cutting-edge research implications for life, earth, and space science. Three years later, most of these teachers have become instructors in Museum-based and Museum distance-learning courses while continuing to work in schools. Others have become school principals and directors or are seeking advanced degrees in science education.

- **Higher Education team for Professional Development Initiatives**: The third dimension of the infrastructure was the development and investment in a professional development team - charged with the design and implementation of programs for teachers. These individuals had advanced degrees and experience in teacher education or in science. The team includes scientists, teacher educators, teachers, and

educational technologists. Scientists came to work in the Education Department as content specialists. Teacher educators shaped professional development days, courses, and institutes to meet teaching standards for certification and licensing. Teachers brought their experience with using Museums for instruction. Educational technologists joined the technology arm of the education department National Center for Science Literacy, Education, and Technology (NCSLET), a center charged with creating Museum programs and products to bring the Museum scientists, their research, and the exhibitions beyond Museum walls. In essence, recognizing its potential as a player in higher education was the Museum's response to the call to action proposed by the National Commission on Teaching and America's Future: What Matters Most, when it asked *"The profession to take seriously its responsibilities to children and America's future. We ask administrators and teachers to take on the difficult work of developing teaching of ever higher quality"* (1996, Summary Report, p.29).

Several years later, the Museum provides Museum-based professional development programs to 5,000 teachers a year. Most of these programs are customized for schools and districts – and all of them include interactions with scientists, study in the Museum exhibits, inquiry-based sessions that address science standards, and distribution of printed and digital curriculum resources that are responsive to standards. Currently, the Museum has different types of professional development collaborations with teacher education institutions. These include Columbia Teachers College, Bank Street College of Education, New York University, and Pace University. A special relationship exists with most of the City University of New York (CUNY) campuses (Lehman College, Brooklyn College, Hunter College, and Queens College). This relationship includes purposeful program development, seeking collaborative funding, and doing collaborative research. These institutions, like the Museum, are public, have the highest resource needs, and educate the largest number of urban teachers who in turn teach or will teach the highest numbers of urban students.

On the technology front, NCSLET has developed a series of eight on-line content courses called Seminars on Science. These courses have gained national recognition with distinguished awards from the Association of Educational Publishers for Education Technology. In 2001, they were selected as one of the technology and education initiatives featured at the National Education Summit co-sponsored by IBM and Achieve, Inc. The United Federation of Teachers is considering sponsoring these seminars as New York City professional development initiatives in the future (Exhibit B- Seminars on Science).

The development of this infrastructure (Bybee, 2001) was the Museum's response to a variety of commission reports, policies, mandates, and teacher shortages that were affecting the nation and New York City in particular. Our decisions were mostly influenced by a set of policies and recommendation that were difficult to ignore. The report form the National Commission on Teaching, recommended to *"Get serious about standards, for both students and teachers; and reinvent teacher preparation and professional development"* (1996, 17-20). Also taken into account were the 1997 reports from the National Center for Educational Statistics (CNES) on the US performance on Third International Mathematics and Science Study (TIMSS); the blueprints and work on teaching standards developed by the Council of Chief State School Officers (INTASC); the National Board of Professional Teaching Standards (NBPTS,1997) for certification of highly qualified teachers; and the science learning standards and benchmarks disseminated by the National Research Council (1996). The need for action was also highlighted by the local conditions. The local media was publishing the names of institutions whose teacher candidates were or were not passing certification tests. In response, New York State Department of Education asked that all programs be reviewed, redesigned, and resubmitted to the state. For us, it was the time to schedule the expedition. We believed we had resources and expertise to offer. Our only research and action question was: What would it take to include Museum learning experiences in the required curriculum for preparing and certifying teachers?

Year 1 – 1998- 1999 Developing a Map for the Expedition

In the first year the Museum focused on two activities: assessing its resources and identifying structures and standards that would be effective in the teacher education arena. In terms of resources, the Museum is a well-known scientific research institution with over 200 research scientists and 35 million artifacts and specimens. Its scientists participate in more than 100 expeditions a year. The education department offers programs for close to 5,000 educators a year, and on a good day 3,000 students visit in class trips. Museum facilities include classrooms for students and for adults. Several miles of exhibition space in twenty-six interconnected buildings. Newly developed cutting edge science exhibits on Biodiversity, Genetics, Earth, and Space Science attract visitors from around the world. It is easily accessible by several means of transportation. It is near Central Park and not far from the Hudson River. It is an ideal and beautiful area to observe, do, learn, and teach science. In the education department there are close to 80 educators and scientists who focus on education and in the development of

on-site and on-line resources and programs. In summary, the Museum resources make it a scientifically rich and educationally accessible "science content" provider. It has worked "informally" with teachers and schools for over 100 years. Now our task was to see how to explore the "formal structures".

We also studied the various documents on teaching standards to select the ones more representative of our expertise – and then developed programs. We focused on the blueprint for NBPTS certification in Early Adolescence Science (Middle School Level). Our various school partnerships included middle schools and we could see direct evidence of some of those competencies in the practices in our classrooms.

Standards for teachers outlined various kinds of knowledge that we could help develop. Teacher could increase their knowledge of science content and of science resources and how to adapt them. They could increase their capacity to develop environments for inquiry; recognize that science is interdisciplinary and occurs in different contexts; and reflect on their practice. The Museum would be able to support the development of most of these competencies through resources, courses and assignments, institutes, and on-line resources.

Review of teaching standards also helped us determine how to structure Museum-based instruction for teachers. We would team-teach because socialization with scientists, teacher educators, and classroom teachers would support the different knowledge areas outlined in the standards. Museum-based learning would be organized as courses, seminars, or institutes according to their intensity and numbers of participants - in the same way that colleges classify them. The number of contact hours would be similar to those required by the state and the colleges to award credit. We also shaped our instructional approaches. In addition to teach teaching our class periods would be longer and probably would meet every other week rather than weekly. These types of schedules would allow time for scientific conceptual changes to take place. Inquiry activities of observation and field study also needed time in between sessions. Also with the team-teaching approach the three instructors would do different sections of the four-hour period, or activities could be done in rotating smaller groups. Assignments and course projects would always call for inquiry-based activities, planned Museum investigations; review of printed and on-line resources, and a performance assessment component required that actual trips with students be planned, implemented, and evaluated during the course session. We field-tested all these approaches and schedules in a fall 1997 course in "*Informal Science*" we designed and taught for Teachers College and have implemented in all courses to date.

The first set of on-line Seminars on Science were also developed and piloted that year. The standards served to organize their content. Museum scientists and curators authored the courses. Teams of scientists, educators, and technology specialists developed these seminars and the teaching team includes a museum scientist and a science educator that serves as "course guide". Seminars were six-weeks long and delivered though the technology platform of Connected University, a division of Classroom Connect. This partnership allowed the Museum to focus on content and resources, while Classroom Connect provided all the technology required for registration and other aspects of course delivery. We invited teams of NYC teachers to take the first set of courses and to serve as participant-observers. In this role they worked closely with the external evaluators that have followed this project throughout the past three years. (Full reporting of this on-line project is presented at AERA session 52.12 for AERA Division K). The external evaluators were Inverness Research Associates. Their evaluation was comprehensive. They looked at content and its organization. They reviewed resources and their appropriateness. They interviewed and surveyed scientists, course guides, and course participants. They even had evaluators take some of the courses. The evaluation of the first pilots called for development of some off-line resources, adaptations in amount of required work, and broader selection of course projects. Their feedback was invaluable. The seminars were revised and additional resources provided. Evaluation of second set of offerings we were very successful.

The most formal, Museum-based activity at the beginning of this year was the "courting of the deans of education" and interested group that was not sure of our intent or of how museum could play a formal part in their programs. Their programs were in transition in response to revisions mandated by New York State but the CUNY Dean of Academic Affairs was quite responsive and encouraging. He took the leadership with his institutions and helped us to develop an agreement by which the formal and informal institutions would share resources to invent initiatives that complemented their existing teacher education programs. Collaboration of the teacher education programs was not required or expected. Their responses would be driven by their needs. By the end the year we felt encouraged in our journey. We had designed and taught our first "teacher education" CUNY course and implemented our first Summer Institute for Educators.

The Dean of Lehman College and the new director of the science program (F. Espinoza) requested that we design a pilot course for "beginning" secondary school science teachers who were entering a funded program at the masters' level. In spring 1999, we piloted *"Museum Resources for Teaching Life, Earth, and Space Science"* for Lehman College. The course was designed as a science curriculum course. It was

taught at the museum by its higher education team. Classes were four hours long and met every other week. Students (First year teachers) received extensive resources and they all brought their students to the museum. In the process they reported learning a great deal about school policy, red tape, and safety regulations. Course evaluations were positive. The following year we were asked to submit the course for approval to the college's curriculum committee. Our own evaluation also encouraged us to develop courses at the masters level rather than undergraduate. The state required it and in the resubmission of new programs – museum courses – were more appropriate. We would do individual sessions or mini-courses for undergraduates – but our resources would mostly focus on the graduate level.

In summer 1998, we offered our first educators' summer institute. We piloted the concept of an institute structure that did three things: offered strong content by Museum scientists and curators, modeled inquiry-based classroom instruction in workshops run by teachers from expeditions and from the partnership schools, and Museum educators demonstrated how to use the Museum for investigations. This structure proved very useful to participants and what they valued the most was the life science content that was the focus of this institute on *Biodiversity*. The institute also had a very enjoyable tone and participants received museum memberships for a year to encourage their continued use of the Museum for learning, enjoyment, and eventually teaching.

Year 2 – 1999-2000 **Expedition Companions**

Year 2 was an exciting, busy, and challenging year. We continued offering the graduate course for Lehman College. Brooklyn College was joining us with its Eisenhower initiatives and one of its faculty members taught a summer course at the Museum after having attended a summer institute with her students. Two other faculty members were interested in using the Museum for several sessions in a Geology Course and in a Life Science Course. Hunter College asked us to design and pilot a Geology Course for Educators. Fernando Espinoza at Lehman documented and published the course collaboration from Year 1.

We offered two summer institutes: Space Science focused on the newly opened Rose Center for Earth and Space and a second one that focused on Earth and Planetary Sciences. Heather Sloan, who at the time was a scientist at the Museum, directed the second institute. She also designed and taught the *"Earth Science for Educators"* course that Hunter College had requested. Two teachers who had been in research experiences assisted Heather Sloan in teaching this course.

"Earth Science for Educators" is an innovative, standards-based, graduate level teacher education curriculum that presents science content and pedagogic technique in parallel. The curriculum calls upon the resources and expertise of AMNH to prepare novice New York City teachers for teaching Earth Science. One of the goals of teacher education is to assure and facilitate science education reform through preparation of K-12 teachers who understand and are able to implement standard-based instruction. Standards reflect not only the content knowledge students are expected to attain but also the science skills and dispositions towards science they are expected to develop. Melding a list of standards with a curriculum outline to create inquiry-based classroom instruction that reaches a very diverse population of learners is extremely challenging. *"Earth Science for Educators"* helps novice teachers make the link between standards and practice by constantly connecting standards with instruction they receive and activities they carry out. Development of critical thinking and enthusiasm for inquiry is encouraged through engaging experience and contact with scientists and their work. Teachers are taught Earth systems science content through modeling of a wide variety of instruction and assessment methods based upon authentic scientific inquiry and aimed at different learning styles. Use of fieldwork and informal settings, such as the Museum, familiarizes novice teachers with ways of drawing on community resources for content and instructional settings. Metacognitive reflection that articulates standards, practice, and the teachers' own learning experience help draw out teachers' insights into their students' learning. The innovation of bring science content together with teaching methods is key to preparing teachers for standards-based, inquiry instruction.

This curriculum was successfully piloted with a group of 28 novice teachers as part of the AMNH-CUNY partnership and the CUNY Teaching Opportunity Program Scholarship. Reactions and feedback from program coordinators and teachers have been extremely positive during the year and a half since its implementation. At the end of Year 2 Heather Sloan took a position at Lehman College, a factor that strengthened our collaboration.

In response to the Museum's invitation to formalize Museum resources for credit-bearing courses at Brooklyn College, we decided to pilot our partnership by incorporating the three-day Educators' Institute on Earth Science, highlighting the new Gottesman Hall of Planet Earth in an earth science course for educators offered in the summer of 1999. This preliminary step in collaborating on a credit-bearing course led to a desire to do more.

The following year Eleanor Miele arranged to teach a graduate-level science education methods course called *Workshop in Elementary Education: Science* at the

Museum. This three-credit course was offered to participants in Brooklyn College's K-9 Mathematics and Science Consortium, sponsored by a grant from the Dwight D. Eisenhower Title IIA Professional Development Program. The mission of the consortium is to improve standards-based teaching of science and mathematics in Brooklyn elementary and middle schools and to increase the number of certified teachers in these schools. The participants were in-service teachers of grades K-9 who were interested in improving their science teaching, most of whom did not yet have permanent certification.

Borrowing from the format of the earth science course, this second course incorporated the three-day Educators' Institute on Space Science. All sessions in this course were held in the exhibit halls and in a laboratory classroom provided by the Museum. The course began with the Institute and continued with six five-hour sessions at the Museum led by Eleanor Miele, a member of the faculty of the School of Education at Brooklyn College, team-teaching with experienced elementary school science teachers. Class sessions included visits to halls, hands-on science investigations relevant to Museum exhibits and student presentations of hands-on lessons relating to Museum exhibits for use with their own students.

Museum artifacts used in the methods course were selected from those that were relevant to the National Science Education Standards and the New York State elementary science syllabus and had readily-available analogous materials that teachers could readily access for hands-on lessons in their classrooms.

The combination of guided use of Museum exhibits and hands-on activities allowed teachers to experience first hand a number of pedagogic approaches to using artifacts to teach topics in space, earth and life science. All activities focused on science concepts including the sun, moon, earth and space, asteroids, food chains, anatomy, life cycles, evolution, the rock cycle, and minerals. Teachers learned to use artifacts to enhance the teaching of core science concepts.

Koshi Dhingra, a new faculty member at Brooklyn College, evaluated this course in an ethnographic study by compiling student journal responses and conducting follow-up interviews with selected participants. Maritza Macdonald and Eleanor Miele presented the results of that evaluation with Koshi Dhingra last year at the AERA annual meeting in Seattle. Participant comments in the final course evaluations indicated that teachers found learning at the Museum was enhanced by the opportunity for hands-on interaction with Museum artifacts. One participant wrote, "Taking a course at the Museum was much different than taking a course in the college. Everything you needed was right in front of you. You could touch most of the items referred to by instructors. It was real, something you rarely get from a book." Teachers gained a sense of the value

of informal educational sites for teaching. For instance, one participant wrote, "This experience helped me to see that sometimes informal settings can teach more than what can be taught in the class."

The evaluation also pointed out that the ability of teachers to bring their students to the Museum to replicate their own experiences with their pupils was limited by the lack of support at the administrative level in public schools for out of school trips. Administrators still view field trips as non-academic. Now, we think of ways to extend include administrators in our programs.

One measure of the success of the methods course at the Museum was the number of participants who subsequently applied for admission to the master's program in elementary science and environmental education at Brooklyn College or to take other courses at the Museum. Of the 12 teacher participants who had not yet completed a master's degree, six applied for matriculation in the science education program. Two participants applied to take a second summer course at the Museum. This high level of interest in pursuing further studies in this program is indicative of substantial student satisfaction.

The Museum collaboration has added value to the master's program. In the affective domain alone there are significant intangible benefits. Our association with the Museum has coincided with an appreciable improvement in student morale. Students take great pride in being included in the community of the Museum. Most of our participants are not yet permanently certified teachers, teaching in areas of high poverty and serving largely immigrant and minority populations. There are limited resources and high student, teacher, and administrator turnover. The pride of association with a world-class institution like the Museum helps to foster an improved self-image for teachers teaching under highly stressful circumstances.

This positive influence extends to the faculty as well. Both full-time and adjunct faculty are willing to travel, meet outside class time and otherwise extend themselves more when teaching at the Museum. The access to artifacts, publications and Museum staff support is motivating to the faculty as well as the students.

It is for this reason Eleanor Miele took steps to institutionalize the partnership with the Museum through the creation of a "new" course at Brooklyn College in *Teaching Science Beyond the Classroom*. This course is technically a revision of an existing, but seldom taught, course on learning environments in science with a new emphasis on learning in museums and parks. The course is now offered at least once each year and is accepted as an elective in the masters programs in childhood and middle childhood science education.

Because we had entered such a productive phase it was important to begin a line of research. This year's work became our first collaborative research effort that was reported last year in Seattle.

The rewards of the Year 2 summer offering were great - but we felt stretched thin. Two science institutes and two Museum-taught courses in the summer were too much for our Museum team. In the future we needed more time for teaching, preparation, reflection and evaluation. We revised the "teacher education" schedule for the following year and were more realistic about the use of teaching space we had available in July. In the summer we would do one summer institute. Teach one summer courses and expand some of its requirements until Augusts. And we would allocate space for one college instructor who had participated in the institute - to continue teaching his/her course at the museum. In the fall semester we would offer the Teachers College Course on *Informal Science* to its graduate students and a Teachers College professor would work with the Museum team. In the spring semester we would teach the Lehman course on *Museum Resources for Teaching Life, Earth, and Space Science.* This course had passed committee approval and was not a pilot anymore.

At the end of the summer our staffing roster changed. Heather Sloan accepted a position at Lehman College. The education department continued to fund an education position for another scientist to replace Sloan. Adriana Aquino, from the Ichthyology department, a seasoned scientist who had experience working with an educators in teaching one of the on-line Seminars on Science joined the team in early 2001.

YEAR 3, 2000-2001

Funding Companions join the expedition and aid the formalization process

In Year 3 we experienced a vote of confidence from three different sources: funding, requests for new required courses, and encouraging evaluations from participating teachers. We received additional funding to support two aspects of the Museum teacher development expedition. First, it provided summer institute scholarships for 100 CUNY scholars in summers 2001 and 2002. Second, it supported resources for the development of additional courses that had the potential of being adopted by CUNY programs.

We reserved 100 spots for CUNY scholars at the 2001 Summer Institute for Educators. Its focus was Genomics, Genetics, and Genethics. All institute activities centered on the research and resources of the Museum exhibit, "The Genomic Revolution," an amazing temporary exhibit with state of the art DNA lab and extensive

use of multimedia to illustrate the scientific and societal implications of the discoveries associated with the sequencing of the human genome. Over 100 teachers and faculty from Lehman, Queens, and Brooklyn College teacher education programs attended the institute. They all received teaching resources and Museum memberships. Their campuses included the institute as part of the summer courses for graduate credit that they took after the institute. The Museum team-taught the Brooklyn College course *Teaching Science Beyond the Classroom* that Miele had piloted the previous summer. Queens College instructor in collaboration with a Museum teacher educator piloted a course for his institution.

In addition to the institute spots for CUNY students the funding also provided resources for Museum-based courses that had been originally designed for on-line courses. Now, Museum-based course participants received essay books written by scientists and CD-ROMs that include scientific lectures and profiles, views of the Museum collections, and animations that support the study of life, earth, and space science. To increase the CUNY faculty's awareness of the on-line Museum resources, interested CUNY faculty members were invited to participate in evaluation and auditing of the Seminars on Science. Another CUNY instructor did observations of the process used by the Museum to design its on-line seminars. We hope that in the future these resources may find their way into the credit-bearing offerings by local institutions.

Another step in the direction of "formalization" took place this year. The Lehman College and the New York State Department of Education (NYSED) approved *"Museum Resources for Teaching Life, Earth, and Space Science"*, as an integral part of the revised Masters of Science Education Program. Resubmission of all teacher education programs in New York State was required by the NYSED in 2000-2001 to meet the newly set standards for teacher preparation. The National Council of Accreditation for Teacher Education (NCATE) is currently reviewing Lehman's Science Education Program and this course is so instrumental in meeting these national standards that it has become a required curriculum and instruction element of the program.

The opinions and evaluation of participants in museum-based courses and institutes is encouraging in four areas:

1) Team-teaching seems effective for socializing teachers into to the world of science, scientists, science teaching, and to Museums as places of learning.
2) Access to a vast array of resources: exhibits, printed, on-line, and Museum memberships seems to be valued by participants;
3) Assignments encourage reflection and evaluation of how museum learning differs from college or school learning; and

4) Seminars on Science seem to be meeting content knowledge needs of educators.

Here we present some of the preliminary responses to questions designed to examine the first three areas. First, what do they learn from different team members? Second, how do they use resources? And third, how do they differentiate learning at the Museum from learning in a formal setting? To answer these questions, Macdonald surveyed teachers sixty teachers who had finished taken courses and who had attended institutes prior to the taking the courses.

Learning from a teaching team composed of scientists, teachers, and teacher educators.

Learning from scientists: Responses to this question seemed to express three main ideas: fascination with the content knowledge in their different fields; admiration for the passion in their subject; and surprised at their responsiveness to teachers.

"It was like talking to a living textbook, but even better. I was quite impressed"

"From scientists I learned a great deal of interdisciplinary material. From the geneticists, I learned about the benefit of genetic research when I had previously "villainized" all research. From the botanist, I learned about the large extent of plant life right around the corner and how to do a biodiversity experiment."

"I learned that they are not as intimidating as I thought. They were very congenial and very willing to share their knowledge and entertain questions in their particular field".

"They love what they are doing unlike some teachers. The Museum scientists enjoy teaching."

"The scientists provided insight into how scientists are using and implementing the tools and knowledge we are teaching in class."

"I learned that a passion for a subject inspires others to want to learn more. The Museum scientists gave me a wealth of knowledge and allowed me to observe how I can use science all around me, even on the sidewalk".

Responses to learning from teachers indicated that they learned to use the Museum for teaching their content. This supports competency in learning to use community resources for instruction – a required competency for certification.

"The teachers offered assistance in guiding me to use the Museum. They helped me to organize and focus on particular areas. The Museum is huge, but with the help of some of these teachers I know how to focus the experience".

"It was beneficial to hear from other teachers' experiences. I got new ideas and was able to share my ideas with them".

"I learned different ways to use the various halls at the Museum. The teachers gave me ideas on what halls to visit, what order to visit them in, and in what particular location to focus on within the halls and possible lesson ideas to accompany the trip".

Interactions with teacher educators were more related to design of curriculum, understanding standards, and designing assessments.

"I learned about the NYC standards and how to apply them to assess my students' accomplishments. This provided a much needed distinction between curriculum and standards".

"They were adept in their planning of subjects to inform and in ways of implementing them at any grade level. The ideas in regards to trips were enlightening to me. It gave me much valuable information about NY".

"I think that now I can understand how subjects taught at school can be related to the Museum".

"I learned that the standards should not be our enemies. It is the assessment that is the difficult part. I learned how to more effectively use free-choice learning to supplement classroom learning".

"I appreciated the fact that they were in tune with the needs of teachers. They were able to hone in on our key interests".

These responses reassured us that exposure to different kinds of professionals is important in the Museum learning context and that each profession makes a contribution.

Learning from Museum resources (exhibits, printed and on-line, memberships)

Museum-based courses and institutes provide participants with many kinds of resources. The following responses gave us a better idea of what they value and why. These responses have implications for developing materials and for including these costs into the instructional costs. When asked how they had used any of the various resources their responses they were specific on what they had used, how, and why.

"I brought my summer school class to the Hall of Planet Earth using the teacher resource guide".

"I have been using the printed materials as resources for myself to build my knowledge and I'll always have them ready for my students to use. They have challenged me in my thinking as a teacher".

"The printed packet helped me find my way through the Museum".

"I used the packets to reinforce some things that I already know. I also gained a lot of new ideas that I can implement in the classroom".

"The on-line resources helped me to gather additional and up to date information in my subject area".

The on-line helped me lose the fear I had about the Museum. I saw that the material was very interesting".

"I checked my DNA sequence".

"I used the on-line resources to gather information for inquiry questions".

"I used on-line resources for research, personal interest, and to get ideas for class trips".

"I used the Hall of Minerals and Gems".

"I used the hall of Gems to make physical science connections".

"Biodiversity Hall – cool"

"I used the Hall of Planet Earth, which is excellent for teaching Earth Sciences".

"I will use the membership to return several times to photograph, develop and expand lessons and to prepare for student visits during the year".

"I will use the membership to explore before bringing my students".

"I will use my membership for coming to performances, events, get the magazine and learn new things"

- Reflecting on learning in different contexts: Museums and schools or college

Reflection on differentiated learning is an important cognitive issue for us. By learning what is it that is different for teachers we might be more certain about the nature of learning, the kinds of knowledge, and the learning styles that each setting may nurture in adult learners. We posed the following question at the end of the course, how was learning at the Museum different from learning on campus or at school? Responses mostly related to the active nature of learning and the exposure to real objects of scientific study.

"Hands-on!! I am here bathing in it".

"I was put in a place where I couldn't easily dream-off. There was an array of stuff to explore and learn from. I was always motivated and disappointed when the time was up".

"I think it is more relaxing and I learned more by observing and touching everything".

"It was much more practical and hands-on compared to learning on campus. We did not have to learn everything from a textbook. That made the class more interesting. We actually experienced the science for ourselves".

We believe that these responses support the main ideas we took into this expedition. We are reassured of our approaches to instruction, the importance of resources, the relevance of inquiry-based experiences, and the reflection into the nature of learning science in this context. We will continue to ask these questions over the next two years. We believe that with a larger sample we would be more confident of our claims on the ways and conditions that Museum-based experiences add to the preparation of science teachers in urban settings with science rich institutions.

The Seminars on Science also have been extensively evaluated. Although they are not currently part of a formal or institutionalized structure – they are an important professional development that brings Museum science to educators. They have passed the field-testing stage; the model for producing the courses is completed. Over 400 teachers have taken the courses. Like with its Museum-based programs – the Museum plans to embark in a dissemination process designed to also find their place in the various systems of professional development for science educators. Here, we present six results that more closely connect with our Museum-based programs: content knowledge, knowing the world of scientists, excitement for learning science, use of Museum resource, and confidence with new instructional approaches (in their case, the use of computers).

- *84% of participants reported increased knowledge of content*
- *76% indicate they have been motivated to continue learning.*
- *83% reported increased knowledge of the world of scientists*
- *73% are motivated to take additional science courses.*
- *81% report using the resources of the course with their students*
- *30% report their colleagues' appreciation of their expertise*
- *30% report feeling more comfortable using computers for learning.*

Preliminary Conclusions: At this mid-point in the expedition we have been able to invent a variety of Museum-based formats for providing instruction and resources to teachers. Partners in various teacher education programs have joined us, we have begun research in this area, and some partners are including our initiatives in their formal offerings.

While the expedition is still in process we recognize five factors that seem to be the cornerstones of this effort. They relate to policy, program structures, trust, evaluation and scholarship, respect, and commitment to teachers and their pupils.

1) We have been guided by reform policies and standards for science teaching;

2) We have designed Museum-learning opportunities in the same ways that formal programs do (courses, seminars, institutes, contact hours, performance assessments, credits);

3) We are exercising scholarship through our documentation, evaluation, revision, and dissemination of our work;

4) We are aware that we (all institutions) have had to be mindful of each other's missions and visions;

5) We are convinced that this "expedition" is not just about "institutionalization" – it is about facilitating access to knowledge and resources.

We have learned much in three years and we hope for a successful completion. In the final year of the study we hope to be able to bring the separate voices of museums, administrators of participating institutions, and faculty that have been involved over several years to speak of their work in this context and to offer their scholarship and wisdom to other programs.

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